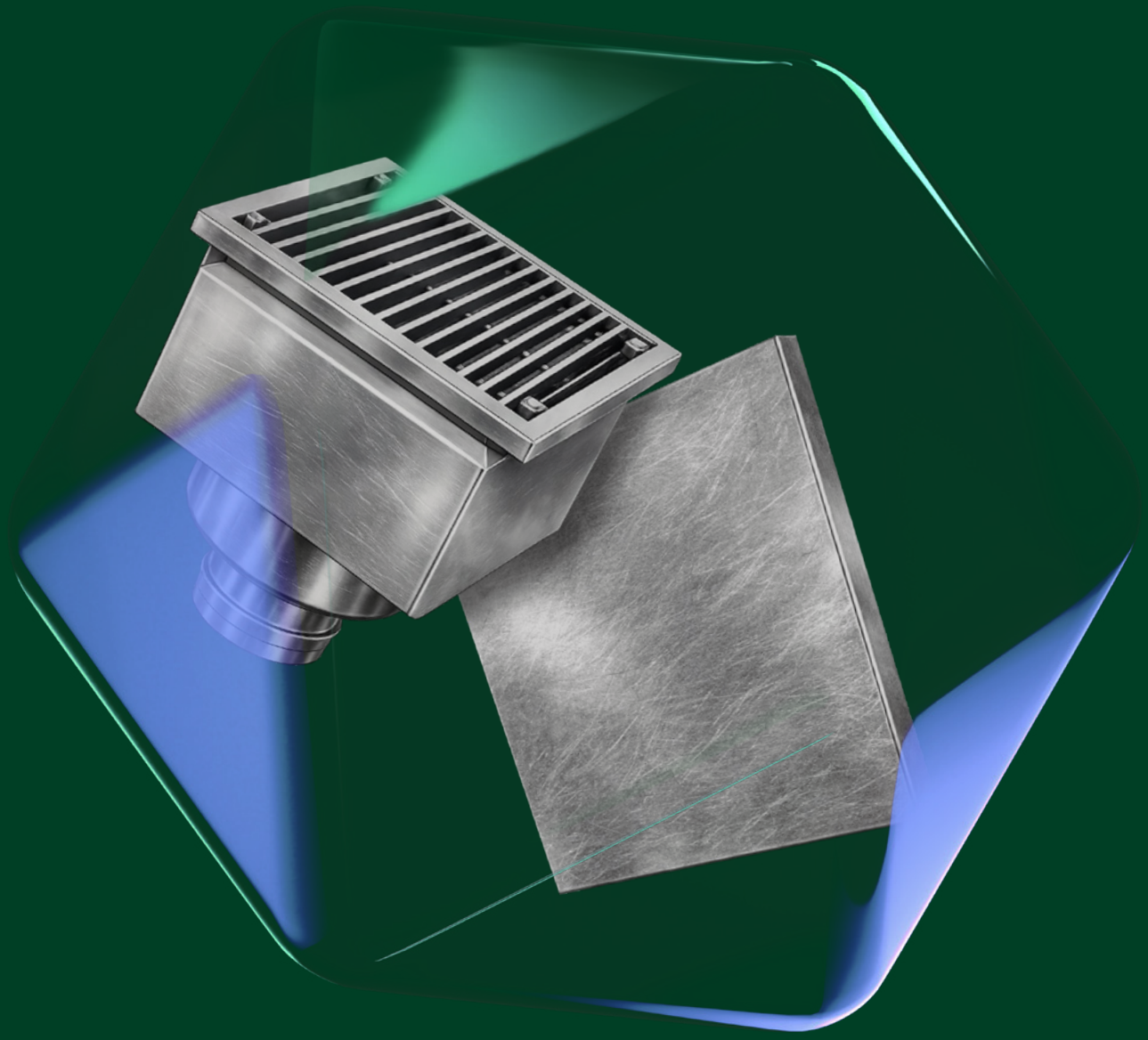
phageguard | Phage technology
Listeria control



How phages protect the production environment against *Listeria*

PGL

Micreos Food Safety B.V. | phageguard.com

Power of bacteriophages

Nature's force for balancing bacteria

Bacteriophages (or phages) are biological entities that serve to maintain the natural balance of bacterial populations. Every 48 hours, phages can reduce half of the world's bacterial population. This effect is due to their immense abundance. Phages are everywhere and outnumber bacteria by a factor of 10, making them the most common microorganisms on our planet. For reference: 1 ml seawater contains 1 billion phages.

The unique ability of phages

Similar to bacteria, phages are extremely diverse, with each phage having the unique ability to target a specific bacterial species down to the level of bacterial strains. This also includes food pathogens encountered in the food industry.

Phages: the future of food safety

Since 2005, Phageguard focused on developing phage solutions that specifically target *Salmonella*, *Listeria*, and pathogenic *E. coli.* Our precision-targeted phage products enable customers to achieve optimal pathogen control, without altering the organoleptic properties of treated foods or compromising natural/organic processing standards.

Phageguard L

The power of anti *Listeria* phages PGL

Designed for the food industry to help protect final products against *Listeria* contamination, Phageguard L (PGL) provides natural control of prevalent *Listeria* spp., including *Listeria monocytogenes*. By leveraging the precise targeting ability of phages, PGL specifically targets *Listeria* and does not impact worker safety or the condition of the production environment and equipment. As a result, PGL acts as a modern shield, improving the *Listeria* management in your production environment while maintaining the integrity of your brand.

- **Effective against prevalent *Listeria* spp.**
- **Water-based solution enabling *Listeria* management in harborage points, like deadspots, irregular crevices, and hollow equipment frameworks**
- **Able to penetrate biofilms compared to traditional treatments, making it highly effective for the inactivation of *Listeria* biofilm formations**
- **Non-hazardous to humans, animals, and plants**
- **Non-corrosive (stainless steel, concrete)**
- **Can be applied to both the environment and the food product itself to offer maximum protection against *Listeria* contamination on the final product**

Listeria protection in every zone of the production environment

Food Contact Surfaces* *and non-Food Contact Surfaces: hotspot examples*

Flooring	Walls	Slicers and cutters
Sewer lines and drains	Filling machines	Refrigeration units
Transport/mobile equipment	Waste containers	Cooling systems

*USA, USDA approved use on Food Contact Surfaces (FCS)
EPA approval for environmental application pending

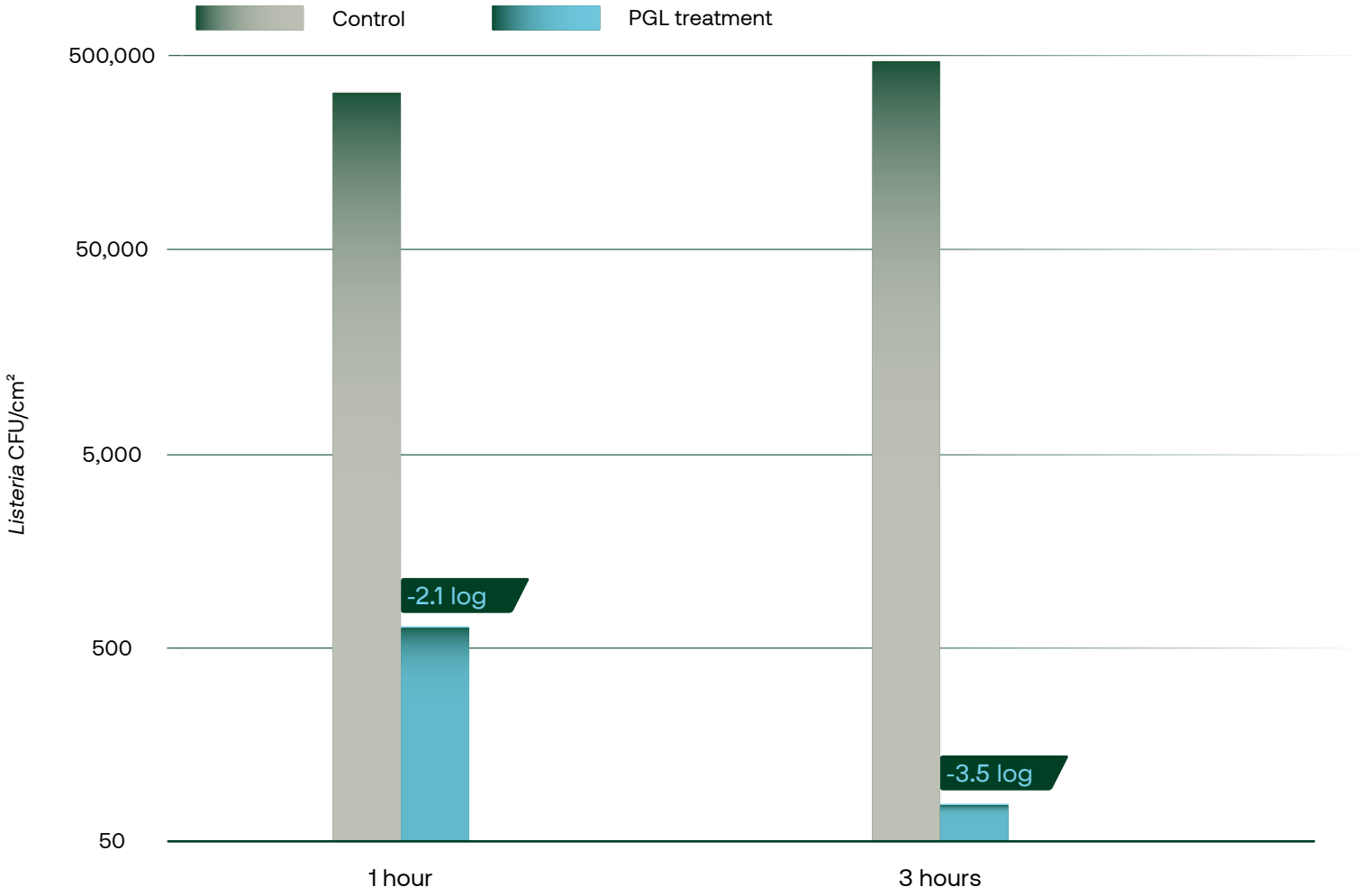
Stainless steel

Reducing *Listeria* on stainless steel surfaces

Phageguard L (PGL) was applied as a single dose treatment to the contaminated stainless steel surface. After 1 hour post-treatment, PGL delivered *Listeria* reductions of 2.1 log. After 2 more hours, PGL delivered further *Listeria* reductions of up to 3.5 log, while continued growth was observed on the control surface.

3.5 log Reduction

A single treatment of PGL reduced *Listeria* on the stainless steel surface by 3.5 log after 3 hours post-treatment.



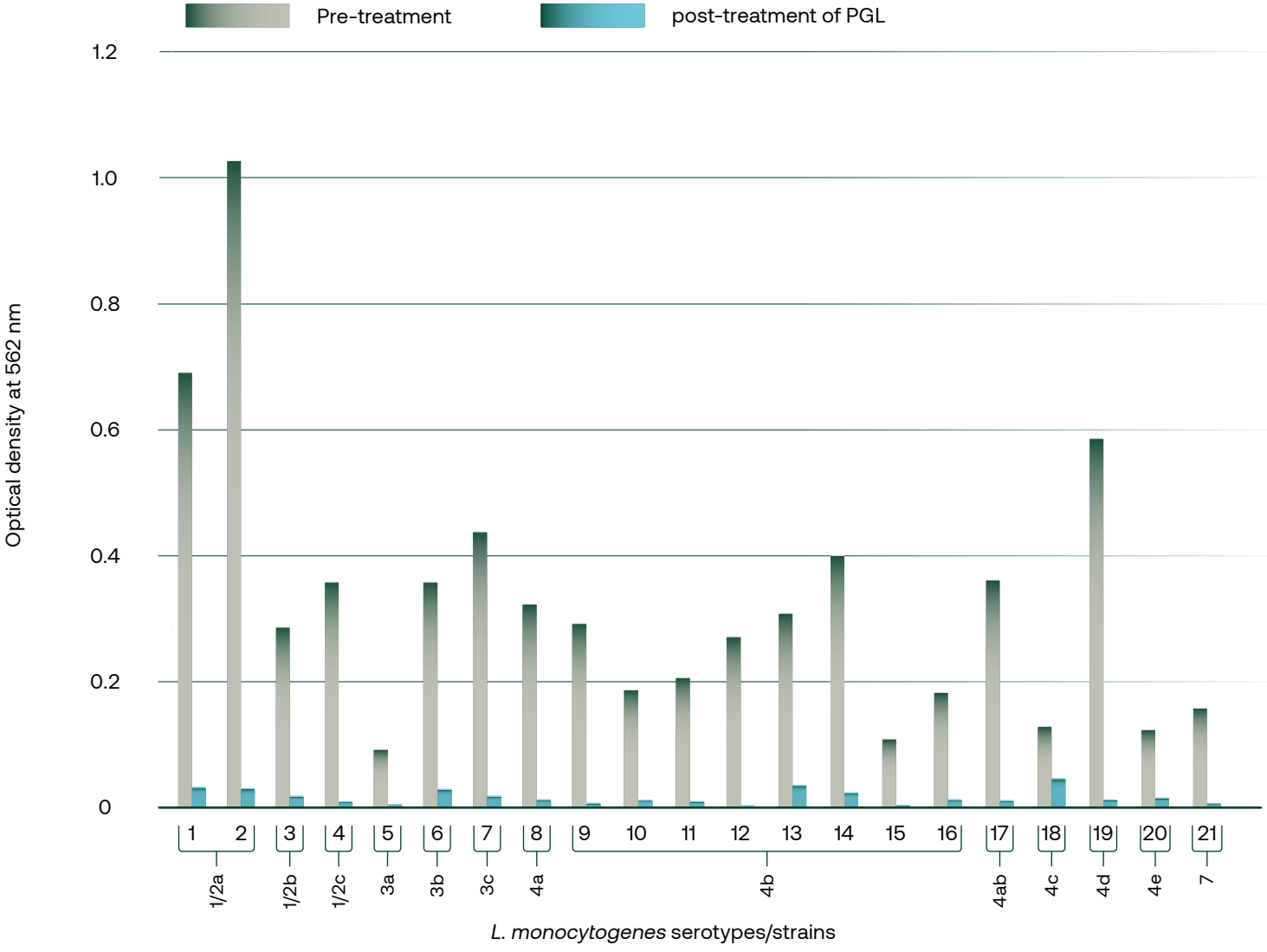
Biofilm removal

Inactivation of *Listeria* biofilms representing 13 different serotypes

Phageguard L (PGL) was applied as a single low-dose treatment to the biofilm. The bars in the chart represent the *Listeria* biofilm size per strain (numbered). The biofilm consisted of 21 different strains, representing a total of 13 *Listeria monocytogenes* serotypes. After 24 hours post-treatment, PGL was able to almost completely inactivate the *Listeria* biofilm.

100%
Sensitivity

A single low-dose treatment with PGL almost completely inactivated the *Listeria* biofilm, representing 13 different *L. monocytogenes* serotypes. Furthermore, all strains present in the biofilm were sensitive to PGL.



Effective management

Food Contact Surfaces (FCS)*

Manual application

Phageguard L (PGL) can be integrated as an additional *Listeria*-specific control step to reduce risk and prevent cross-contamination from equipment to product. PGL offers versatile implemenrtation in daily cleaning procedures or as a dip treatment for utensils (knives, scoops) during production.

Environmental

Manual application

Fogging

PGL can be integrated into existing Environmental Monitoring Programs (EMP) to improve control of *Listeria* on non-Food Contact Surfaces (non-FCS). Due to its non-hazardous characteristics, PGL is suitable for application through fogging systems, allowing effective distribution and coverage for controlling *Listeria* in the production zone within the reach of the fogging mist.

Biofilm removal

Manual application

PGL can be used as a treatment for the inactivation of detected *Listeria* biofilms. Depending on the age of the biofilm (older biofilms tend to be more persistent), PGL can on average inactivate biofilms within 2–7 treatments. This is due to phages being the natural predators of bacteria, enabling PGL to penetrate the biofilm, unlike traditional treatments that primarily target the biofilm surface.

*USA, USDA approved use on Food Contact Surfaces (FCS)
EPA approval for environmental application pending

Compliance

Trusted by government institutes around the globe

Phageguard L (PGL) has received approvals from government agencies around the globe and has been GRAS affirmed by the FDA since 2006. Furthermore, PGL is OMRI-organic listed, produced in an FSSC 22000 certified facility, and both halal and kosher certified to ensure alignment with a broad range of salmon processors.

- ✓ USA, FDA GRAS (GRN 218) - 2006
- ✓ USA, USDA approved processing aid (Directive 7120.1) – 2007
  - ⓘ Approved use for Food Contact Surfaces (FCS)*
- ✓ Canada, Health Canada: Processing aid – 2011
- ✓ Australia/ New Zealand. FSANZ processing aid – 2012
- ✓ Israel, Food Control Services Ministry of Health: approved processing aid – 2014
- ✓ Chile, Undersecretary of Public Health (MINSAL) (ORD. B34/N794) - 2022
- ✓ Dubai, DM Food Safety Department - 2025
- ✓ Costa Rica, Ministry of Health of the Government of Costa Rica - 2026

FSSC 22000 OMRI LISTED® HALAL EUROPE CERTIFICATION UNDER SUPERVISION OF THE CHIEF RABBINATE OF HOLLAND

*USA, USDA approved use on Food Contact Surfaces (FCS)
EPA approval for environmental application pending

Partnerships

Collaborations with universities and research institutes

Phageguard has collaborated with numerous universities and research institutes to build a strong scientific foundation supporting our applied phage technology for controlling food pathogens. Published studies over the years demonstrate its effectiveness, versatile application across various food products, and compatibility with other food safety interventions in multi-hurdle approaches commonly used in industry.

The Americas

University of Nevada | Mississippi State University | California Polytechnic State University | Cornell University | University of Connecitcut | University of Maryland | University of Wisconsin-Madison | Oregon State University | Food Science Institute | McMaster University | Aemtek | Instituto Tecnológico de Querétaro | Universidade Federal da Bahia

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Europe

WUR Wageningen University | ETH Zürich | University of Ghent | Utrecht University | Institut Pasteur | Insitut du Porc | Nofima | TNO | Universidad D Cordoba | Universitat de Lleida | Radboud University | Max Ruber Institute | BfR Institute for Risk Assessment | Quadram Institute | Food Valley | Aristotle University of Thessaloniki | Universtitat de Lleida | Nizo | IFIP | CEBAS | CSIC | ISS | RCT Gelderland | Oost NL | Han University of Applied Sciences | Saxion Hogeschool | DIL | KU Leuven

Supporting the industry

Study cases and industrial implementations

The following overview presents the food applications in which Phageguard currently supports the industry, as well as the R&D projects that further explore the versatility of phage implementation to expand our services.

PGL Industrial implementations - *Listeria* control

- Fish
- Crustaceans
- Dairy
- Ready-to-eat matrices
- Meat
- Fruits
- Vegetables
- Fresh pet food
- Production surfaces

PGL Research & Development projects - *Listeria* control

- Hydroponics

Phage technology
Listeria control

Applied phage technology to control food pathogens

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